

# Claims

- [c1] 1. Microfluidic device comprising at least one cavity disposed within its body and at least two ports in connection with said cavity, wherein at least one port of each cavity faces same direction, and said microfluidic device is employed at some point as a temporary storage of fluids disposed into said cavity and storage period exceeds 15 seconds.
- [c2] 2. Microfluidic device of claim 1 comprising solid lid part, wherein said lid has at least one nearly flat surface, and said surface may form nearly airtight fixed contact with at least one port containing side of said device, and said contact is formed after disposing liquids into said device.
- [c3] 3. Microfluidic device of claim 1 comprising flexible lid part, wherein said lid has at least one nearly flat surface, and said surface may form nearly airtight fixed contact with at least one port containing side of said device, and said contact is formed after disposing liquids into said device.
- [c4] 4. Microfluidic device of claim 1 comprising solid lid part, wherein said lid has at least one nearly flat surface, and

said surface may form nearly airtight contact with at least one port containing side of said device, and said contact is formed after disposing liquids into said device, and said lid can be removed from said device at least once without damaging or contamination of said device.

[c5] 5. Microfluidic device of claim 1 comprising flexible lid part, wherein said lid has at least one nearly flat surface, and said surface may form nearly airtight contact with at least one port containing side of said device, and said contact is formed after disposing liquids into said device, and said lid can be removed from said device at least once without damaging or contamination of said device.

[c6] 6. Microfluidic device comprising at least one cavity disposed within its body and at least two ports in connection with said cavity, wherein at least one port of each cavity faces same direction, and at least one other port of each cavity faces opposite direction, and said microfluidic device is employed at some point as a temporary storage of fluids disposed into said cavity and storage period exceeds 15 seconds.

[c7] 7. Microfluidic device of claim 6 that comprises solid lid part, wherein said lid has at least one nearly flat surface, and said surface may form nearly airtight fixed contact with at least one port containing side of said device, and

said contact is formed after disposing liquids into said device.

- [c8] 8. Microfluidic device of claim 6 that comprises flexible lid part, wherein said lid has at least one nearly flat surface, and said surface may form nearly airtight fixed contact with at least one port containing side of said device, and said contact is formed after disposing liquids into said device.
- [c9] 9. Microfluidic device of claim 6 comprising solid lid part, wherein said lid has at least one nearly flat surface, and said surface may form nearly airtight contact with at least one port containing side of said device, and said contact is formed after disposing liquids into said device, and said lid can be removed from said device at least once without damaging or contamination of said device.
- [c10] 10. Microfluidic device of claim 6 comprising flexible lid part, wherein said lid has at least one nearly flat surface, and said surface may form nearly airtight contact with at least one port containing side of said device, and said contact is formed after disposing liquids into said device, and said lid can be removed from said device at least once without damaging or contamination of said device.
- [c11] 11. Microfluidic device of claim 6 comprising two solid lid

parts, wherein said lids have at least one nearly flat surface, and said surface may form nearly airtight contact with at least one port containing side of said device, and said contact can be formed after disposing liquids into said device.

[c12] 12. Microfluidic device of claim 6 comprising two flexible lid parts, wherein said lids have at least one nearly flat surface, and said surface may form nearly airtight contact with at least one port containing side of said device, and said contact can be formed after disposing liquids into said device.

[c13] 13. Microfluidic device of claim 6 comprising two solid lid parts, wherein said lids have at least one nearly flat surface, and said surface may form nearly airtight contact with at least one port containing side of said device, and said contact can be formed after disposing liquids into said device, and at least one of said lids can be removed from said device at least once without damaging or contamination of said device.

[c14] 14. Microfluidic device of claim 6 comprising two flexible lid parts, wherein said lids have at least one nearly flat surface, and said surface may form nearly airtight contact with at least one port containing side of said device, and said contact can be formed after disposing liquids

into said device, and at least one of said lids can be removed from said device at least once without damaging or contamination of said device.

[c15] 15. Microfluidic device comprising at least one channel and said channel having at least one opening to nearly flat open surface, and said surface contains surface segment with high affinity to desired fluid and said surface segment is directly adjacent to said opening, and shape of said surface segment selected in such a way that shift of some liquid volume away from said opening causes reduction in contact area between said liquid and said surface shape, and said liquid volume is deposited on said surface from an external source, wherein said external source is any means or device that is not an integral part of said microfluidic device.

[c16] 16. Microfluidic device comprising plurality of devices of claim 15 wherein some subset of said devices has openings oriented in nearly same direction and facing same or nearly coplanar surfaces.

[c17] 17. Microfluidic device comprising at least one channel and said channel having at least one opening to nearly flat open surface, and said surface contains surface segment with high affinity to desired fluid and said surface segment is directly adjacent to said opening, and shape

of said surface segment selected in such a way that shift of some liquid volume away from said opening causes reduction in contact area between said liquid and said surface shape, and said liquid volume is deposited on said surface from an external source, where is said external source is any means or device that is not an integral part of said microfluidic device, and said surface shape contains at least one feature with positive curvature that significantly higher than some other features of said shape, and said surface segment has electrical conductivity noticeably higher than adjacent surface regions, and said device is employed in such a way that said conductive surface feature carries electrical potential above +3 volts or below -3 volts, and said potential exists for more than 50 microseconds.

[c18] 18. Microfluidic device comprising plurality of devices of claim 17 wherein some subset of said devices has openings oriented in nearly same direction and facing same or nearly coplanar surfaces.

[c19] 19. Microfluidic device comprising:  
i) at least one opening to a surface, wherein said surface can be exposed partially or as a whole to a gas phase for at least some period of time, and said opening serves as a port allowing diffusion of vapors of a liquid solvent  
ii) at least one opening supplying vapors of said liquid

solvent to volume of space adjacent to said first opening, wherein concentration/pressure of vapor provided by this port is equal or exceeds concentration/pressure of vapors escaping through said first port.

[c20] 20. Microfluidic device according to the claim 19 comprising a gel containing said solvent substance as a source of vapors for plurality of said second openings.

[c21] 21. Microfluidic device according to claim 19 comprising porous inorganic material holding part of said solvent substance as a source of vapors for plurality of said second openings.

[c22] 22. Microfluidic device according to claim 19 comprising integral chamber that holds said solvent substance as a source of vapors for plurality of said second openings.

[c23] 23. Method of dispensing droplets of liquid with volumes less than one microliter onto nearly smooth surface, wherein said surface comprises plurality of ports and at least some of said ports are in liquid communication with integral chambers or channels, and said dispensing is carried out in gaseous environment containing at least 90% partial pressure of Helium gas, and said surface is later exposed to gaseous environment containing less than 10% partial pressure of Helium gas.

[c24] 24. Microfluidic device comprising at list one chamber and said chamber comprising at least two ports, wherein said ports have openings to nearly flat surfaces, and normals of said surfaces are nearly parallel and there are at least two ports associated with the same chamber while having different area of cross section, and said device is employed during deposition of a liquid or a soluble substance to a surface of physical body positioned in direct proximity from at least on of said ports.

[c25] 25. Microfluidic device according to claim 24 that is employed for deposition of said liquids or soluble substances to a surface of said physical body, wherein said body surface made from elastomeric material.

[c26] 26. Microfluidic device according to claim 24 that is employed for deposition of said liquids or soluble substances to a surface of said physical body, wherein said body surface made from rigid material.

[c27] 27. Microfluidic device comprising at list one chamber and said chamber comprising at least two ports, wherein said ports have openings to nearly flat surfaces, and normals of said surfaces are nearly counter parallel and there are at least two ports associated with the same chamber while having different area of cross section, and



said device is employed during deposition of a liquid or a soluble substance to a surface of physical body positioned in direct proximity from at least one of said ports.

[c28] 28. Microfluidic device according to claim 27 that employed for deposition of said liquids or soluble substances to a surface of said physical body, wherein said body surface made from elastomeric material.

[c29] 29. Microfluidic device according to claim 27 that employed for deposition of said liquids or soluble substances to a surface of said physical body, wherein said body surface made from rigid material.

[c30] 30. Microfluidic device that comprises:

- i) at least one channel;
- ii) cavity that has opening to said channel and is completely sealed otherwise, wherein surface of said channel has affinity to specific liquid higher than said exposed opening of said cavity, and said channel has at least one downstream port and said downstream port creates passive energy barrier that is capable of stopping propagation of minute volume of said liquid, and energy required to overcome said barrier is lower than energy required for said liquid to cross region of said channel with said opening, and said cavity filled with fluid immiscible with said liquid or gas.

[c31] 31. Microfluidic device comprising:

- i) at least one channel;
- ii) cavity that has opening to said channel, wherein surface of said channel has affinity to specific liquid higher than said exposed opening of said cavity, and said channel has at least one downstream port and said downstream port creates passive energy barrier that is capable of stopping propagation of minute volume of said liquid, and energy required to overcome said barrier is lower than energy required for said liquid to cross region of said channel with said opening, and said cavity filled with fluid immiscible with said liquid or gas, and where said cavity has second opening or channel connecting said cavity with another volume containing said gas or fluid.

[c32] 32. Microfluidic device comprising:

- i) at least single channel;
- ii) cavity that has opening to said channel and is completely sealed otherwise, wherein surface of said channel has affinity to specific liquid higher than said exposed opening of said cavity, and said channel has one downstream port that immediately adjacent to said opening and said downstream exposed to first segment of nearly flat surface and said first surface segment is surrounded by surface segments that have lower affinity to specific

liquid than said first surface segment, and said cavity filled with fluid immiscible with said liquid or gas.

[c33] 33. Microfluidic apparatus that employs ordered array of microfluidic devices of claim 30.

[c34] 34. Microfluidic apparatus that employs ordered array of microfluidic devices of claim 31.

[c35] 35. Microfluidic apparatus that employs ordered array of microfluidic devices of claim 32.

[c36] 36. Microfluidic device comprising at least one surface and said surface comprising:

i) plurality of surface features that are capable of constraining mobility of micro volume of a liquid to single path;

ii) at least one surface feature that merges or intersects one of first surface features, and said surface features are employed in gaseous environment that contains nearly saturated vapors of said fluid.

[c37] 37. Microfluidic device according to claim 36 wherein said second surface feature located on nearly flat surface region that is nearly coplanar with surface region containing first said feature.

[c38] 38. Microfluidic device according to claim 36 wherein

said second surface feature represented by port connected to surface cavity or micro channel located disposed in body of said microfluidic device.

[c39] 39. Microfluidic device according to claim 36 that is employed for mixing of at least two reagents, wherein each reagent represented by minute amount and mixing operation completely consumes both reagents.

[c40] 40. Microfluidic device according to claim 36 that is employed for mixing of at least two reagents, wherein each reagent represented by minute amount and mixing operation completely consumes at least one reagent and at least one reagent is consumed partially.

[c41] 41. Method of passive propulsion of micro volume of a liquid, wherein said micro volume is less than one microliter and more than ten zeptoliters, and method of said propulsion uses loss of chemicals from said micro volume and said chemicals are other than solvent forming said micro volume, and said chemicals are deposited on a surface, wherein said surface interfaces with said micro volume and said chemicals alter energy of interaction between said solvent and said surface.

[c42] 42. Method of passive propulsion of micro volume of a liquid, wherein said micro volume is less than one mi-

croliter and more than ten zeptoliters, and method of said propulsion uses gain of chemicals by said micro volume and said chemicals are other than solvent forming said micro volume, and said chemicals are deposited on a surface, wherein said surface interfaces with said micro volume and said chemicals alter energy of interaction between said solvent and said surface.

[c43] 43. Method of passive propulsion of at least two distinct micro volumes of liquids, wherein both of said micro volumes are less than one microliter and more than ten zeptoliters, and method of said propulsion uses loss of chemicals by one of said micro volumes and said chemicals are other than solvent forming said micro volume, and said chemicals are deposited on a surface, wherein said surface interfaces with said micro volume and said chemicals alter energy of interaction between solvent of said first micro volume and said surface, and said propulsion uses gain of chemicals by another one of said micro volumes and said chemicals are other than solvent forming said second micro volume, and said chemicals are deposited on said surface by said first micro volume, wherein said surface interfaces with said second micro volume and said chemicals alter energy of interaction between solvent of said second micro volume and said surface.

- [c44] 44.Method of passive propulsion of micro volume of a liquid, wherein said micro volume is less than one microliter and more than ten zeptoliters, and method of said propulsion uses loss of chemicals from said micro volume and said chemicals are other than solvent forming said micro volume, and said chemicals are disposed in form of vapors from surface of meniscus of said micro volume, wherein said meniscus interfaces with surface of enclosed micro channel and said chemicals alter surface free energy of said solvent.
- [c45] 45.Method of passive propulsion of micro volume of a liquid, wherein said micro volume is less than one microliter and more than ten zeptoliters, and method of said propulsion uses absorption of chemicals by said micro volume and said chemicals are other than solvent forming said micro volume, and said chemicals are transferred in form of vapors to surface of meniscus of said micro volume, wherein said meniscus interfaces with surface of enclosed micro channel and said chemicals alter surface free energy of said solvent.
- [c46] 46.Method of claim 41 wherein said micro volume contains at least two chemicals that both contribute to said passive propulsion.

- [c47] 47.Method of claim 44 wherein said micro volume contains at least two chemicals that both contribute to said passive propulsion.
- [c48] 48.Method of claim 45 wherein said vapors contain at least two chemicals that both contribute to said passive propulsion.
- [c49] 49.Microfluidic device comprising at least one micro channel, wherein method of claim 41 is employed to move minute volumes of liquid in said micro channel.
- [c50] 50.Microfluidic device comprising at least one micro channel, wherein method of claim 42 is employed to move minute volumes of liquid in said micro channel.
- [c51] 51.Microfluidic device comprising at least one micro channel, wherein method of claim 43 is employed to move minute volumes of liquid in said micro channel.
- [c52] 52.Microfluidic device comprising at least one micro channel, wherein method of claim 44 is employed to move minute volumes of liquid in said micro channel.
- [c53] 53.Microfluidic device comprising at least one micro channel, wherein method of claim 45 is employed to move minute volumes of liquid in said micro channel.
- [c54] 54.Microfluidic device comprising a surface with plurality

of geometric features, and at least one feature employed as a constraint that restricts degrees of motion freedom of a micro volume of a fluid and said device employs method of claim 41 to move said volume along said constraint.

[c55] 55. Microfluidic device comprising a surface with plurality of geometric features, and at least one feature employed as a constraint that restricts degrees of motion freedom of a micro volume of a fluid and said device employs method of claim 42 to move said volume along said constraint.

[c56] 56. Microfluidic device comprising a surface with plurality of geometric features, and at least one feature employed as a constraint that restricts degrees of motion freedom of a micro volume of a fluid and said device employs method of claim 43 to move plurality of fluid volumes along said constraint.

[c57] 57. Method of sorting of micro droplets of a fluid, wherein said microdroplets have volume between one microliter and ten zeptoliters, and said sorting is done based on exposure of plurality of chemical compound of said fluid on surface of said droplet, and effect of said exposure on interaction energy between said droplet and at least one surface region of a substrate contacting with



said droplet, and said sorting results in geometrical motion of said droplets by distinct trajectories.

[c58] 58.Method of sorting according to claim 57, wherein at least one of said compounds is amphiphilic.

[c59] 59.Method of sorting according to claim 57, wherein at least one of said compounds present in amount between 0.5 and 5 percent by mass in said droplet.

[c60] 60.Method of sorting according to claim 57, wherein at least one of said compounds present in amount between 0.05 and 0.5 percent by mass in said droplet.

[c61] 61.Method of sorting according to claim 57, wherein at least one of said compounds present in amount between 0.005 and 0.05 percent by mass in said droplet.

[c62] 62.Method of sorting according to claim 57, wherein at least one of said compounds present in amount between 0.0005 and .005 percent by mass in said droplet.

[c63] 63.Method of sorting according to claim 57, wherein at least one of said compounds present in amount less than 0.0005 percent by mass in said droplet.

[c64] 64.Microfluidic device for manipulating micro droplets of fluids that comprises plurality of microchannels and their intersections, and said intersections comprise intersec-

tions that have geometrical plane or axis of symmetry oriented parallel to flow direction, and said device employs the method of claim 57.

[c65] 65. Microfluidic device for manipulating micro volumes of fluids that comprises plurality channels or surface features that has fractal like structure and is employed for purpose of sorting or analysis of continuous or discrete micro volumes of said fluids.

[c66] 66. Method of controlling evaporation rate of solvents from non-enclosed surfaces of micro volumes of fluids, wherein said micro volumes are disposed in microfluidic device or on any substrate with generally flat surface and said fluids have a part of surface interfacing with gaseous compounds and said gaseous compounds exist in unsealed space, and said method uses temperature difference between said fluids and said gaseous compounds to induce directed diffusion of said gaseous compounds toward said interface, and wherein each volume of said single fluid are less than ten microliters.

[c67] 67. Method of deposition of microdroplets of fluids into microfluidic device or onto any substrate with generally flat surface, wherein said microfluidic device or substrate has higher gravitational potential energy than source of said fluids at the moment of transfer and each volume of

said single fluid is less than ten microliters and target surface region of said substrate or microfluidic device is oriented toward said source.

[c68] 68. Method of controlling evaporation rate of solvents from non-enclosed surfaces of micro volumes of fluids, wherein said micro volumes are disposed in microfluidic device or on any substrate with generally flat surface and said fluids have a part of their surface interfacing with gaseous compounds and said gaseous compounds exist in unsealed space, and said unsealed space is in gaseous connection with laminar flow of gaseous media that contains vapors of some of said compounds at concentration at least 98 percent of maximum stable concentration of said vapors at current pressure and temperature of said stream.

[c69] 69. Apparatus implementing method of claim 66 and has no automated means for replacement of said microfluidic device or substrate.

[c70] 70. Apparatus implementing method of claim 67 and has no automated means for replacement of said microfluidic device or substrate.

[c71] 71. Apparatus implementing method of claim 68 and has no automated means for replacement of said microflu-

idic device or substrate.

[c72] 72.Apparatus implementing method of claim 66 that comprises:

i) feed-forward control means to adjust temperature of said microfluidic device or substrate to temperature required by said method without overshooting;

ii) means for automated placement and removal of said microfluidic devices or substrate onto said apparatus.

[c73] 73.Apparatus implementing method of claim 67 that comprises means for automated placement and removal of said microfluidic devices or substrate onto said apparatus.

[c74] 74.Apparatus implementing method of claim 68 that comprises means for automated placement and removal of said microfluidic devices or substrate onto said apparatus.

[c75] 75.Apparatus for precision control of temperature and concentration of at least one vapor in gaseous volume, where in said volume is not sealed and has opening that at least one eighth of its total surface and is less than ten centimeters in at least one dimension, and is designed to maintain relative pressure of said vapors above 90 percent in said volume and prevent said vapors from uncon-

trolled escape from said volume that could raise their concentration above 80 percent in any adjacent location besides said volume.

[c76] 76.Apparatus that comprises:

- i)electrostatic ionization source and oppositely charged electrode, where in said source and said electrode are positioned in a stream of saturated vapors of some compound and said source is located upstream and said electrode is located downstream;
- ii) support member located downstream from said source and capable of holding or supporting microscale substrate or device, where in said substrate or device has artificially created features and at least one of them has dimension less than one millimeter.

[c77] 77.Apparatus according to claim 76 and claim 75 further implementing methods according to claim 66 and claim 68, wherein said apparatus does not have any means for automated replacement of said microfluidic device or substrate.

[c78] 78.Apparatus according to claim 76 and claim 75 further implementing methods according to claim 66 and claim 68, wherein said apparatus have means for automated replacement of said microfluidic device or substrate.

- [c79] 79. Microfluidic device comprising:
- i) at least one microfluidic channel;
  - ii) at least one optical fiber integrated therein, wherein said optical fiber is capable of at least transmitting at least one milliwatt of at least single monochrome light that belongs to UV, visible or infrared ranges, and said light is penetrating volume of said channel and induces motion of chemical compounds or other physical matter that may include viruses and living cells in said channel.
- [c80] 80. Microfluidic device according to claim 79 wherein light source is laser with UV wavelength.
- [c81] 81. Microfluidic device according to claim 79 wherein light source is laser with visible wavelength.
- [c82] 82. Microfluidic device according to claim 79 wherein light source is laser with infrared wavelength.
- [c83] 83. Method of separation of different chemicals or distinct micro particles or other physical matter that may include viruses and living cells from a liquid mix wherein said mix forms a laminar flow and said flow is irradiated by one or plurality of sources of light in direction nearly normal to its flow.
- [c84] 84. Method of concentration of chemicals from a liquid mix wherein said mix forms a laminar flow and said flow

is irradiated by one or plurality of sources of light in direction nearly normal to its flow.

[c85] 85. Microfluidic device comprising:

- i) single micro channel for input of liquid mix of chemicals or other physical matter that may include viruses and living cells;
- ii) plurality of outputs;
- iii) at least one optical fiber. Wherein there is a laminar flow of liquid in direction from said input channel to at least one output, and said optical fiber transmits light in direction nearly normal to said flow.

[c86] 86. Microfluidic device comprising:

- i) at least one micro channel and a detector associated with said channel;
- ii) at least one optical fiber. Wherein light from at least one fiber intersects the volume of said channel and said light is focused, and in case of multiple fibers at least some of them have common focal points, and said focal point are located upstream from said detector.

[c87] 87. Microfluidic device according to claim 86 wherein at least one light source for said fibers is synchronized with said detector.

[c88] 88. Method of moving minute amounts of physical mat-

ter, wherein said matter comprises but not limited to individual molecules, fluids, solid or semisolid particles, live cells, viruses, and where in said method comprises use of coherent source of light and means of direction of said light onto device supporting said matter, and where in said light belongs to infrared, visible or UV range and said motion caused by gradient of temperature in proximity of said matter and said gradient is caused by absorption of said light.

[c89] 89.Apparatus for manipulating minute amounts of physical matter in microfluidic device, wherein said apparatus comprises:

- i) one or more sources of coherent light;
- ii) some means for direction of said light;
- iii) means for modulation of said light;
- iv) microfluidic device or their plurality or predefined place for position of said devices;
- v) digital controller or other digital processing device.

Wherein said light sources are in infrared, visible or UV ranges, and said matter is living or not, and said means of modulation may include modulation of light intensity and/or position of beam or beams of light and/or splitting of single beam into multiple beams.

[c90] 90.Method according to claim 88, wherein volume of said matter is more than one femtoliter.



- [c91] 91.Method according to claim 88, wherein volume of said matter is less than one femtoliter and more that one attoliter.
- [c92] 92.Method according to claim 88, wherein volume of said matter is less than one attoliter and more that one zeptoliter.
- [c93] 93.Method according to claim 88, wherein volume of said matter is less than one zeptoliter.
- [c94] 94.Apparatus according to claim 89, wherein modulation means include diffraction grid and array of digitally controlled micro-mirrors.
- [c95] 95.Apparatus according to claim 88, where in at least two light sources have different wavelength.
- [c96] 96.Microfluidic device integrated with memory device, wherein said memory device contains information specific to the instance of said microfluidic device, and where in said information contains at least one of the following:
- i) geometrical dimensions and tolerances;
  - ii) calibration data;
  - iii) known defects;
  - iv) defects locations;

- v) processing history;
- vi) in-process data;
- vii) access rights.

[c97] 97. Microfluidic device of claim 96, wherein said memory device is semiconductor memory device.

[c98] 98. Microfluidic device of claim 96, wherein said memory device is magnetic memory device.

[c99] 99. Microfluidic device of claim 96, wherein said memory device is optical memory device.

[c100] 100. Microfluidic device of claim 96, wherein said memory device is read only memory device.

[c101] 101. Microfluidic device of claim 96, wherein said memory device is writing-once memory device.

[c102] 102. Microfluidic device of claim 96, wherein said memory device is rewritable memory device.

[c103] 103. Optical device comprising plurality of optical components and at least one source of coherent infrared or ultraviolet light and said optical components focus said light to plurality of focal points and said points are aligned with specified locations inside electrophoretic wells.

[c104] 104.Optical device of claim 103 wherein power level changes of said light source are synchronized with voltage source for said electrophoretic system.

[c105] 105.Optical device of claim 104 wherein said electrophoretic system is microfluidic device or is component of microfluidic device.